

# Detector design for HL-LHC in FreeCAD using python scripts

*Monday 5 July 2021 17:10 (30 minutes)*

The LHC machine is planning an upgrade program which will smoothly bring the luminosity to about  $5-7.5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ , to possibly reach an integrated luminosity of  $3000-4000 \text{ fb}^{-1}$  over about a decade. This High Luminosity LHC scenario, HL-LHC, starting in 2027, will require an upgrade program of the LHC detectors known as Phase-2 upgrade. As part of the HL-LHC detector upgrade programme, the CMS experiment is developing a new Outer Tracker with reduced material budget, higher radiation tolerance, and inbuilt trigger capabilities.

While powerful proprietary CAD (Computer Aided Design) and CAE (Computer-Aided Engineering) software is traditionally used in the design phase of modern detectors, these softwares only provide limited scripting capabilities. Instead, FreeCAD is a customizable, open-source parametric 3D CAD built from scratch to be totally controlled by Python scripts.

In this presentation, we will show how Python scripting in FreeCAD has been used to develop, study and validate the design of services for the CMS Outer Tracker Endcaps, and how it can be used to prepare for the assembly of the detector. This approach is shown to provide an excellent interoperability with the rest of the HEP ecosystem and an exceptionally quick turnaround during development.

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**Session Classification:** Plenary Session Monday